



POSITIVE NEGATIVE GAME APPLICATION DESIGN BASED ON THE MONTESSORI METHOD AS A MEANS OF IMPROVING THE MATHEMATICAL CONNECTION ABILITY OF STUDENTS WITH ADHD

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Abstract

The objectives of the study are: 1) to develop a positive negative game application based on the Montessori method to improve the mathematical connection skills of students with ADHD, 2) to determine the characteristics of the mathematical connection skills of students with ADHD, and 3) to determine the mathematical connection skills of students with ADHD after using the developed positive negative game application based on the Montessori method. The method of this study is R&D with the ADDIE model. The findings in this study obtained that the results of the assessment of the three material and media experts with an average percentage of 76.32 valid criteria. From the results of trials conducted on 7 students with ADHD from SLB C Dharma Asih Pontianak, the results obtained were 96.88 for the class teacher's response, the percentage for the response of students with ADHD was 75.89 and 86.38 for the overall average with the criteria "very practical". Based on calculations related to classical completeness, 6 students were obtained complete and 1 student did not complete with the KKM of mathematics subjects set for Phase D level (equivalent to junior high school) in SLB C for Mentally Disabled, namely 65. Furthermore, the effectiveness result was 85.71% with a very effective category. This means that the Positive Negative Game Application Based on the Montessori Method is effective. The conclusions in this study are: 1) Based on the results of the validity, practicality, and effectiveness values, the Design of the Positive Negative Game Application Based on the Montessori Method developed is suitable for use. 2) the characteristics of the mathematical connection abilities of students with ADHD are already in the category of classically complete students from a total of 7 students who worked on the posttest questions. 3) the mathematical connection abilities of students with ADHD after using the Positive Negative Game Application Based on the Montessori Method experienced classical completeness which showed an increase.

Keywords: game applications, positive negative, Montessori, mathematical connection skills, ADHD.

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INTRODUCTION

The background of this research is that one of the abilities that needs to be improved from a cognitive aspect is mathematical connections (Lutfiani & Dewi, 2023). This is in line with the goals of Indonesian education in Law Number 20 of 2003 Article 3, namely to develop students' capacity



to become individuals who believe in and fear God Almighty, have good morals, be healthy, knowledgeable, capable, creative, independent, and become democratic citizens who are responsible for their actions (Bakhril et al., 2019). Through mathematical connection skills, students can fully engage in mathematics learning, becoming knowledgeable and capable individuals. However, in practice, mathematical connection skills are still considered low. This is reinforced by the results of the 2018 PISA study, which showed that students' mathematical connection skills in Indonesia are still relatively low (Rafidah et al, 2020) become a new problem and applies to students with special need. According to Mz et al (2024), Learning mathematics is often considered difficult, especially for students with ADHD. Children with Attention Deficit Hyperactivity Disorder (ADHD) are among those with special needs (Susiaty et al, 2021). According to Nurfadhillah et al (2021) Equalizing learning opportunities for children with special needs is based on the 1994 Salamanca Statement, which expands on the Education For All (EFA) goals. This statement makes mathematical connection skills a crucial factor for students with ADHD to achieve equal opportunities in mathematics learning.

According to Fitriyani et al (2023) Children experiencing ADHD symptoms do not necessarily have low intelligence, but rather behavior and a tendency to over-activity. This has led to the emergence of learning strategies that can facilitate students with ADHD's motivation to learn mathematics. One such approach is implementing a Montessori-based positive-negative learning game application. This application can be used by teachers to teach students with ADHD about integer operations. Games have the potential to revitalize children's determination and motivation to learn (Putra et al, 2023). According to Umair & Tawakal (2021) Through educational games, children can learn while playing. Educational games, which are typically played to relieve boredom, can also be designed as a learning experience so that those who want to learn don't find the learning process boring (Aula et al, 2020; Wiryaningtyas et al, 2023; Yulianti & Ekohariani, 2020). Meanwhile, what is meant by Montessori is a method with characteristics that emphasize activities and adapting the child's learning environment to their developmental stage (Imamah, 2019). Montessori created a learning model that is suitable and appropriate to children's needs (Nadiastuti et al, 2024). Through a Montessori-based positive and negative game application learning system that adapts learning to suit children's needs, the mathematical connection skills required by students with ADHD can be achieved optimally.

The research problems are: 1) how to develop a positive-negative game application based on the Montessori method to improve the mathematical connection skills of students with ADHD. 2) what are the characteristics of the mathematical connection skills of students with ADHD. 3) how are the mathematical connection skills of students with ADHD after using the developed positive-negative game application based on the Montessori method. The urgency of this research lies in the need for a new mathematics learning system for students with ADHD. Children with ADHD can be restless, have difficulty concentrating, and act without control due to impulses, which makes learning mathematics difficult. To improve the mathematical connection skills of students with ADHD, the solution provided is to develop a positive-negative game application based on the Montessori method.

METHOD

This research was conducted at a junior high school (SLB) in Pontianak City, West Kalimantan. The subjects were seventh-grade students from one class at the SLB. The research used the ADDIE model development research design, which included analysis, design, development, implementation, and evaluation, as shown in Figure 1.



Figure 1. ADDIE Design

This research was conducted over a period of one year (2025-2026). The research procedures were as follows. 1) Before conducting a user needs analysis which aims to produce a positive and negative game application based on the Montessori method which is suitable for the characteristics of students with ADHD in Pontianak City, create instruments used in research activities and validate the instruments used to produce valid and reliable instruments. After the instrument was declared feasible, a needs analysis was conducted, consisting of a needs analysis and a student characteristics analysis. The needs analysis was conducted to determine the needs of teachers and students with ADHD regarding the use of learning media in the form of game applications that can support the teaching and learning process in the classroom. A characteristics analysis was conducted to determine the characteristics of users (teachers and students with ADHD) to determine their level of technology use, interest, and motivation in the mathematics learning system. 2) Next, the development steps are as follows: a) Analysis, containing a literature study including curriculum analysis, learning tools, learning methods and models, analysis of learning resources and related journals, field surveys including observation of the learning process, observation of media used in learning, interviews with teachers and students with ADHD who are accompanied by teachers. Materials in the mathematics lessons developed, and infrastructure, a team of teachers who teach at one of the Special Schools (SLB) in Pontianak City. b) Design, is the stage for designing a product according to the needs and analysis that has been done previously. In the design stage, the steps taken are determining the objectives of the product, designing a scenario or storyboard, designing and designing the interface or interface. In general, this Design stage is focused on designing a prototype of a positive and negative game application based on the Montessori method, which includes the preparation of a flowchart (storyboard) and research instruments, used to determine the flow of the research plan being carried out, The research instruments created include material and media expert validation questionnaires, student response questionnaires, pretest and posttest questions, system design and creation, and circuit design aimed at determining the layout of the system to be created by inserting integer operation questions. In addition to being used to determine component layout, the system circuit also has the advantage of reducing excess budget costs. c) Development, steps in realizing the design into reality. In the development steps carried out are realizing the planning, creating software/game applications with the programming language used, validating the learning game application, and revising the learning game application. Expert Validation, so that the developed game application can be used so it needs to be validated by material and media experts, each with 3 experts. Limited trials, so that the developed game application can be used in the classroom, measurements need to be carried out by testing the game application on a small scale, namely in one class in one of the SLB in Pontianak City. Field trials, to obtain direct input related to the developed game application in the form of responses, reactions, comments, from observers carried out on a large scale, namely in several classes in one of the SLB in Pontianak City. d) Implementation, the use of

positive and negative game applications based on the Montessori method developed for Special School (SLB) students in Pontianak City. e) Evaluations, collecting data on the mathematical connection abilities of Special School (SLB) students in Pontianak City in using the developed game application. The level of validity, practicality and effectiveness in this study was determined by the criteria in Tables 1, 2 and 3.

Table 1. Product Validity Criteria

Percentage (%)	Validity Criteria
$80\% < Score \leq 100\%$	Very Valid
$60\% < Score \leq 80\%$	Valid
$40\% < Score \leq 60\%$	Fairly Valid
$20\% < Score \leq 40\%$	Less Valid
$0\% < Score \leq 20\%$	Invalid

(Hodiyanto et al, 2020)

Table 2. Product Practicality Criteria

Percentage (%)	Practicality Criteria
$80\% < Score \leq 100\%$	Very Practical
$60\% < Score \leq 80\%$	Practical
$40\% < Score \leq 60\%$	Quite Practical
$20\% < Score \leq 40\%$	Less Practical
$0\% < Score \leq 20\%$	Impractical

(Hodiyanto et al, 2020)

Table 3. Product Effectiveness Percentage Criteria

Percentage (%)	Effectiveness Criteria
$80\% < Score \leq 100\%$	Very Effective
$60\% < Score \leq 80\%$	Effective
$40\% < Score \leq 60\%$	Quite Effective
$20\% < Score \leq 40\%$	Less Effective
$0\% < Score \leq 20\%$	Ineffective

(Hodiyanto et al, 2020)

RESULTS AND DISCUSSION

This research was conducted using the Research and Development (R&D) approach, referring to ADDIE, which includes Analysis, Design, Development, Implementation, and Evaluation. The development steps are described as follows: (1) Analysis. The analysis stage is the initial stage before conducting research and development to obtain the information needed in developing the Positive Negative Game application based on the Montessori Method as a means of improving the mathematical connection skills of students with ADHD. Mathematical connections in general are internal (in mathematics) and external (outside mathematics) relationships. Internal relationships are relationships between mathematical ideas and mathematics, whether currently being studied or other mathematics (Julaeha et al, 2020). Mathematical connections are one of the abilities that students must master so that when students are able to make connections in mathematics, then these students are able to solve mathematical problems, reason and prove mathematical theorems or axioms, and even be able to represent mathematics into representations that are easy to understand, both by mathematicians and non-mathematicians (Hidayati & Jahring, 2021). Mathematical connections aim to enable students to connect one concept with another in mathematics and other disciplines (Lutfiani & Dewi, 2023). In the initial stage, researchers conducted pre-research to determine the problems

faced by classroom teachers in special needs schools and students with ADHD in relation to the mathematics learning process. Children with Attention Deficit Hyperactivity Disorder (ADHD) are among those with special needs (Susiatiy et al., 2021). According to Hayati & Apsari (2019) Without specially designed assistance, children with ADHD will have difficulty learning optimally and developing their potential. The results of interviews conducted by researchers with class teachers during pre-research obtained information that the media commonly used in mathematics learning is only paper with circles or other flat shapes containing pictures of objects such as balls, flowers and so on and writing about calculations on both sides of the picture which is still not interesting enough for students with ADHD to read it, resulting in a lack of curiosity in students with ADHD towards mathematics learning materials. Furthermore, the rapid changes in mood of students with ADHD make the mathematics learning delivered less than optimal

(2) Design. The second stage is the design stage, this stage is carried out to design a development product that is adapted to the problems encountered in the field during the analysis stage. The design stage of the Montessori Method-Based Positive Negative Game application is described in detail as follows: preparation of a flowchart (storyboard) and research instruments, used to determine the flow of the research plan to be carried out, research instruments created such as material and media expert validation questionnaires, student and teacher response questionnaires, post-test questions. The game application can be used by teachers in providing instruction related to integer operations material to students with ADHD. System design and creation, the creation of a circuit design aims to determine the layout of the system to be created by inserting integer operation questions. In addition to being used to determine the layout of components, the system circuit also has the advantage of reducing excess budget costs.

(3) Development is a step in realizing the design into reality. In the development step carried out is realizing the planning, creating software/game applications with the programming language used, validating the learning game application, and revising the learning game application. Expert Validation, so that the developed learning media can be used so it needs to be validated by material and media experts, each as many as 3 experts. Limited trial, so that the developed media can be used in the classroom, it is necessary to carry out measurements by testing the media on a small scale, namely in one of the classes at SLB C Dharma Asih Pontianak, which is a SLB for the Mentally Disabled. The following is the documentation of the implementation of the small-scale trial in Figure 2.



Figure 2. Small-Scale Documentation of the Positive Negative Game Application Based on the Montessori Method at SLB C Dharma Asih Pontianak

Field trials, to obtain direct feedback related to the developed media in the form of responses, reactions, and comments from observers, were conducted on a large scale in several classes at a special needs school in Pontianak City. The following is documentation of the implementation of the large-scale trial in Figure 3.



Figure 3. Large-Scale Documentation of Positive Negative Game Applications Based on the Montessori Method at SLB C Dharma Asih Pontianak

The values or results of the validation given by the validator can be seen in Table 4.

Table 4. Validity of Assessment Results of Material Experts and Media Experts

Research Instrument	Validator			Average Total Score (%)	Criteria
	1	2	3		
Material	80,80	77,60	71,20	76,53	Valid
Media	73,33	83,33	71,67	76,11	Valid

The assessment results for the material validation included 25 statements, and the media validation results included 11 statements. Table 1 shows the assessment results from the three material experts and media experts with an average percentage of 76.32, with valid criteria. Although the material and media validation results were categorized as valid, several revisions were made by the validators. Based on the input and suggestions provided, the researcher revised the validators' suggestions. These results are relevant to the research conducted by (Gumilang et al, 2019) regarding the validity of a learning media product that is developed.

The results of the validation by the validator on the media and materials obtained several improvements to the media and materials provided. After providing suggestions and input for improvement, the experts also provided an assessment of the Montessori Method-Based Positive Negative Game Application using the material and media validation instrument. The three experts stated that the Montessori Method-Based Positive Negative Game Application could be used with the condition of improvement. Then the data or values obtained from the validation instrument sheet were calculated. The values obtained were valid for the material and media. In addition, the Montessori

Method-Based Positive Negative Game Application must be improved before being distributed to test subjects for field testing (large scale). After improvements were made to HOTS-based Android Gamification and have been declared valid, the product developed can be used for testing during the research. (4) Implementation. After the Montessori Method-Based Positive Negative Game Application is declared valid and improvements have been made to several suggestions by the validator, the product can then be tested as a learning medium to see its practicality. From the results of the trial conducted on 7 students with ADHD from SLB C Dharma Asih Pontianak, West Kalimantan, the results were obtained in table 5.

Table 5. Practicality of the Class Teacher and Student Response Questionnaire with ADHD

No	Aspect	Evaluation	Criteria
1	Class Teacher Response	96,88	Very Practical
2	Responses of Students with ADHD	75,89	Practical
	Average	86,38	Very Practical

From table 5, the results obtained were 96.88 for the class teacher's response, the percentage for the response of students with ADHD was 75.89 and 86.38 for the overall average with the criteria of "very practical". Based on the data from the questionnaire results of the class teacher's responses and the responses of students with ADHD above, it is known that the Positive Negative Game Application Based on the Montessori Method is practical so it can be used as a learning medium in the learning process in the classroom, especially in mathematics. This is also reinforced by previous research conducted by (Lijina, Panjaitan, & Wahyuni, 2020) as the results of the average student with ADHD on the interest indicator in the study of the response of students with ADHD to learning media reached 75% with a very strong category, thus making the learning media more practical. The class teacher also hopes that the Positive Negative Game Application Based on the Montessori Method as a Means of Improving Mathematical Connection Abilities can be applied to students with ADHD. (4) Evaluation. At this stage, the effectiveness of the Positive Negative Game Application Based on the Montessori Method as a Means of Improving Mathematical Connection Abilities of Students with ADHD that was developed is seen. The results of the tests that have been conducted by researchers to students with ADHD in the form of mathematical connection ability test questions for 7 students with ADHD who come from SLB Dharma Asih Pontianak, West Kalimantan. Based on calculations related to classical completeness, 6 students completed and 1 student did not complete with the KKM for mathematics subjects set for Phase D level (equivalent to junior high school) at SLB C Tunagrahita, namely 65. Based on classical completeness data, 85.71% was obtained, which showed an effectiveness result of 85.71% with a very effective category.

Overall, the mathematical connection skills of ADHD students at Dharma Asih Special Needs School in Pontianak are in the good category. This is indicated by a classical completion rate of 85.71%, where six out of seven students have achieved scores above the set Minimum Competency (KKM). These results indicate that most students have been able to meet the three indicators of mathematical connection skills: connecting between mathematical concepts, connecting mathematics with other disciplines, and connecting mathematics with everyday life problems. Meanwhile, one student who has not achieved completion still has difficulty integrating mathematical concepts, requiring more individualized and sustainable learning strategies. This means that the Montessori Method-Based Positive Negative Game Application learning media is effective. Therefore, it can be concluded that after seeing the results of the validity, practicality, and effectiveness values, the Montessori Method-Based Positive Negative Game Application Design as a Means of Improving the Mathematical Connection Ability of Students with ADHD that was developed is in accordance with the initial expectations in this study. The following is a display of the Montessori Method-Based Positive Negative Game Application presented in Figure 4.



Figure 4. Display of the Positive Negative Game Application Based on the Montessori Method

Furthermore, in this study, the characteristics of the mathematical connection abilities of students with ADHD were analyzed and obtained, which were in the category of 85.71% of students completing the class as a whole from the 7 students who worked on the posttest questions on mathematical connection abilities.

This study was limited to the number of subjects, involving only seven students with ADHD at the Dharma Asih Special Needs School in Pontianak. This number reflects the situation in the field, where classes in special needs schools are limited to a maximum of seven students to ensure optimal learning and mentoring. Therefore, although a classical completion rate of 85.71% was achieved, the results of this study only describe the characteristics of students' mathematical connection skills in the research context and cannot be broadly generalized to all students with ADHD in other schools or regions.

Discussion

The assessment results from three material and media experts showed that the average percentage of 76.32% fell into the valid category. This indicates that in terms of content, presentation methods, and the suitability of the media design to the needs of students with ADHD, this application meets the eligibility criteria for use as a mathematics learning aid, particularly for the concept of positive and negative integers. This validity indicates that: 1) The game material aligns with the Phase D curriculum (equivalent to junior high school) at SLB C; 2) Montessori components, such as concrete and visual activities, have been implemented appropriately; 3) The media supports learning that is friendly to the learning styles of students with ADHD.

The results of the application trial on seven students with ADHD showed a practicality score in the very practical category, namely: 1) Classroom teacher response: 96.88% (very high), 2) Student response: 75.89%, and an overall average: 86.38%. This indicates that: 1) Teachers found the application easy to use, supported the learning process, and did not require excessive technical training. 2) Students were able to use the application independently with minimal assistance. 3) The app's Montessori features (interactive, exploratory, and non-burdensome) have been successfully adapted to digital technology. This high level of practicality also reflects the app's suitability to the needs of special needs settings, which often face limited human and technological resources.

Based on the posttest results, it was found that: 1) 6 out of 7 students completed learning ($\geq$ KKM 65), 2) 1 student had not completed it, 3) So the classical completion was 85.71%, which is included in the very effective category. From this it can be concluded that this application helps ADHD students in: 1) Understanding the relationship between integer concepts and real-life situations; 2) Connecting visual representations and mathematical symbols; 3) Demonstrating quantitatively measurable improvement. These achievements reinforce the idea that Montessori-based design,

which utilizes concrete activities, digital manipulatives, and a flexible learning rhythm, is highly appropriate for the cognitive profile of students with ADHD.

The characteristics of the mathematical connection skills of students with ADHD after using the application indicate that most students have achieved the classical completion category. This indicates that students are able to: 1) Relate integer operations to everyday contexts; 2) Solve story-based problems; 3) Use visual representations (number lines, colors, animations) to solve problems. These achievements support the theory that multisensory and exploratory learning, such as that offered by the Montessori method, is highly effective for students with attention deficit hyperactivity disorder (ADHD). This study demonstrates that the use of pedagogically and psychologically tailored educational technology can bridge the learning gap for students with special needs. In this context, students with ADHD: 1) Are more motivated to learn mathematics; 2) Experience measurable cognitive improvements; 3) Experience an inclusive and empowering learning environment. This reinforces the importance of differentiated instructional design in special education. Overall, the findings in this study confirm that the Positive Negative Game Application Design Based on the Montessori Method: 1) Is suitable for use based on validation by experts; 2) Is practical and easy to implement in the learning of students with ADHD in special needs schools; 3) Is effective in improving mathematical connection skills, as reflected in the high classical mastery of students. The use of this application provides a concrete solution to address the challenges of learning mathematics for students with ADHD, and is evidence that technological innovation combined with the right pedagogical approach can improve the quality of inclusive education.

The results of this study are in line with previous research, namely the development of geometric puzzle game media that is appropriate to students' needs, appropriate, interesting and useful (Susiati & Prihatin, 2021), Then the Montessori method-based positive-negative board teaching aid is suitable as a learning medium to help students with ADHD (Susiati et al., 2021). Then, Yuliana et al (2022) stated that the Android-based math educational game developed is suitable for use. Furthermore, Susiati & Firdaus (2024) conveying the use of positive negative boards based on the Montessori method on the mathematical connection abilities of junior high school students to reach a suitable level.

CONCLUSION

The conclusions in this study are: 1) Based on the results of the validity, practicality, and effectiveness values, the Design of the Positive Negative Game Application Based on the Montessori Method developed is suitable for use. 2) The characteristics of the mathematical connection abilities of students with ADHD are already in the category of classically completed students from a total of 7 students who worked on the posttest questions. 3) The mathematical connection abilities of students with ADHD after using the Positive Negative Game Application Based on the Montessori Method experienced classical completion which showed a significant increase.

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